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VERTICAL DIRECTIONALITY OF LOW FREQUENCY AMBIENT NOISE IN THE S--ETC(U)

JAN 82 D G BROWNING, N YEN, R W BANNISTER

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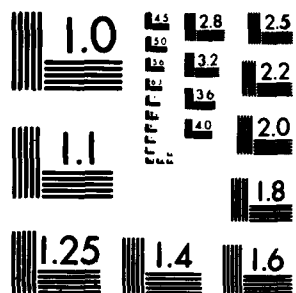
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## **Vertical Directionality of Low Frequency Ambient Noise in the South Fiji Basin**

**A Paper Presented at the 102nd Meeting of the  
Acoustical Society of America, 2 December 1981,  
Miami Beach, Florida**

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**Naval Underwater Systems Center  
Newport, Rhode Island / New London, Connecticut**

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### **Preface**

This document was prepared under the sponsorship of the Undersea Warfare Technology Office, Naval Sea Systems Command, under NUSC Project No. A65005, *Ambient Noise Characteristics*; NAVSEA Program Manager, F. J. Romano, and NUSC Principal Investigator, D. G. Browning.

**Reviewed and Approved: 21 January 1982**



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This document presents the oral and visual presentation entitled "Vertical Directionality of Low Frequency Ambient Noise in the South Fiji Basin," presented at the 102nd Meeting of the Acoustical Society of America, 2 December 1981, in Miami Beach, Florida. The vertical directionality of ambient noise has been measured at two sites in the South Fiji Basin for the frequency range 10-200 Hz. The results are compared with the depth dependence of omnidirectional data taken pre-		

20. (Continued)

viously at the same location. (R. W. Bannister, J. Acoust. Soc. Am., Suppl. 1, 60, S20 (1976).) For frequencies above 100 Hz, the measured noise is uniformly distributed throughout the water column and is principally due to local wind generated noise. Below 100 Hz, there is an additional broad peak in level centered at the deep sound channel axis. This peak is apparently due to long range noise sources received via SOFAR propagation paths. An analysis of the standard deviation could not determine conclusively whether these distant noise sources were storms or ships.

## Vertical Directionality of Low Frequency Ambient Noise in the South Fiji Basin

### Introduction

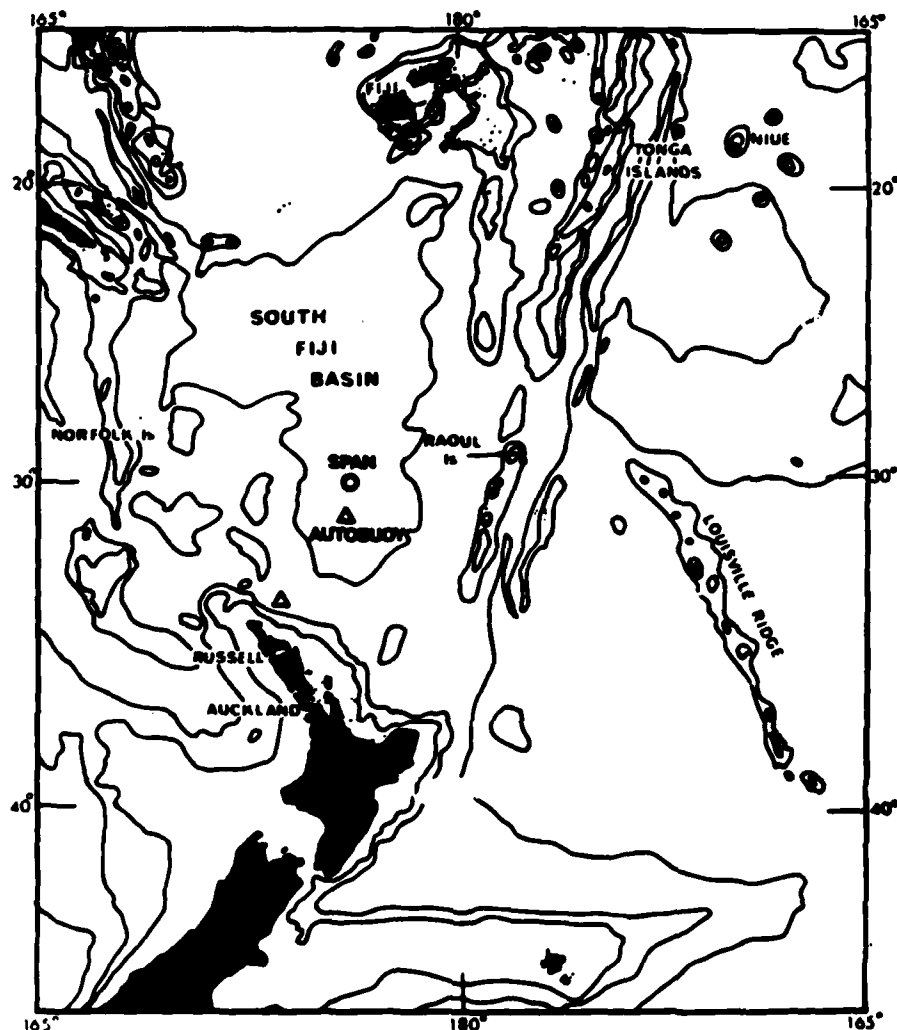
In heavily trafficked ocean areas, such as those that occur in the North Pacific or North Atlantic Oceans, experimental results indicate that ambient noise can be represented by wind generated noise at high frequencies with a rapid transition, at about 100 Hertz, to a constant shipping noise component at low frequencies.

Recent omnidirectional data from the South Pacific, a remote area with a relatively low shipping density typical of the vast Southern Hemisphere Oceans, indicate the situation below 100 Hertz is more complex, with shipping noise, wind-generated noise, and perhaps other sources competing for dominance.

This paper presents the first vertical noise directivity measurements from the South Pacific and compares them to modeling predictions and previously reported omnidirectional data.

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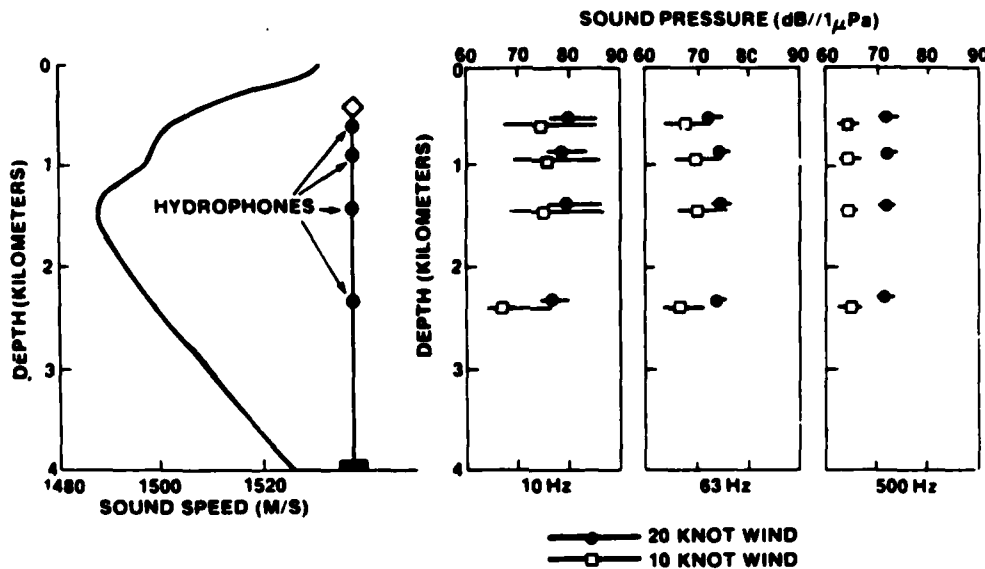
Slide 1

The measurements were conducted in the South Fiji Basin located to the north of New Zealand (the island at the bottom of this figure).

This large basin is surrounded by ridges that provide some isolation from outside noise, but also allow the possibility of coupling surface generated noise into the deep sound channel, as Ron Wagstaff of SACLANT Centre has recently suggested.

Several years ago Jack Northrup also showed that low angle arrivals, such as generated by far distant ships, could literally skip across such ridges.

# PROJECT SPAN THREE AMBIENT NOISE DEPTH DEPENDENCE



## Slide 2

A summary is given here of earlier omnidirectional measurements, which we reported at the previous ASA meeting in Ottawa. Four hydrophones were located at various depths relatively near the sound channel axis. The sound speed profile is shown on the left.

Three representative frequencies were chosen.

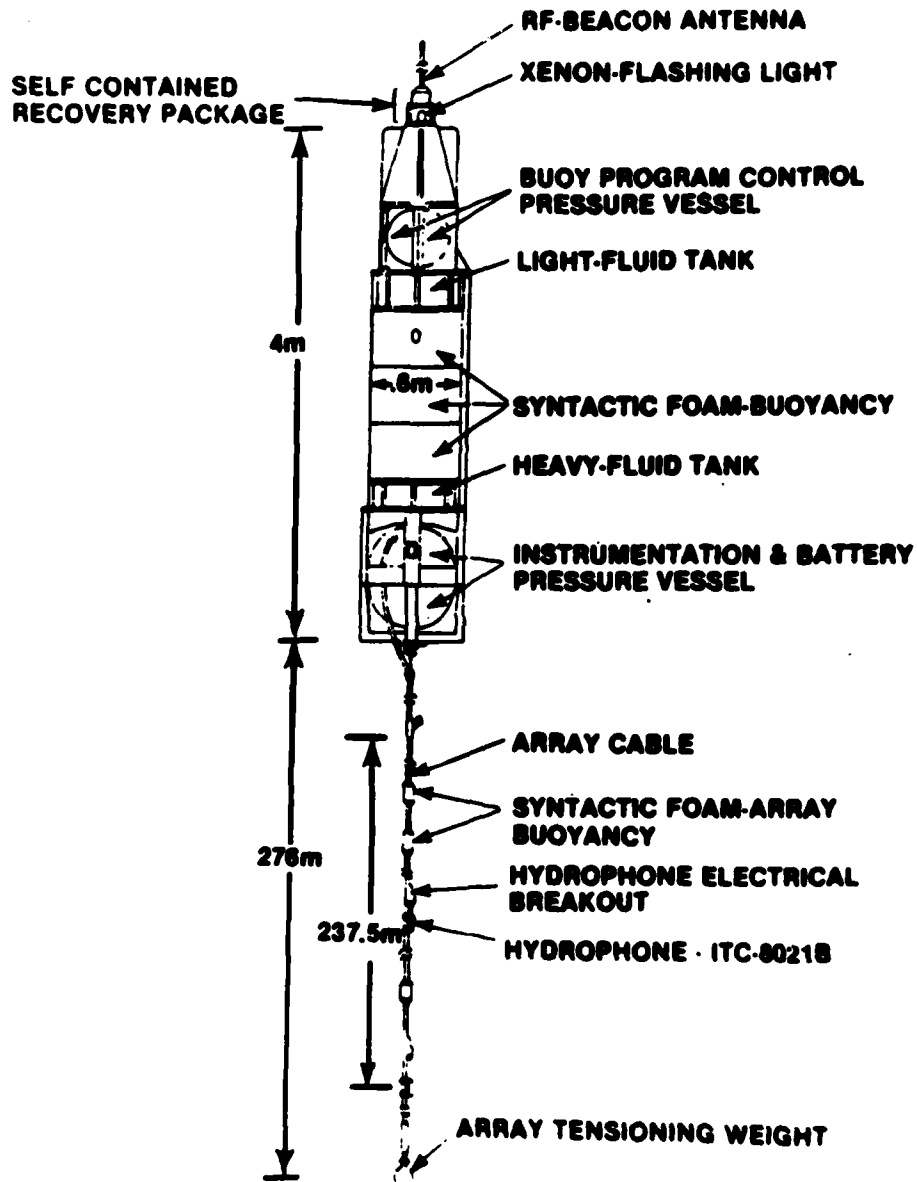
For 500 Hertz (shown on the right), the depth dependence was slight, the variability small and characteristic of wind-generated noise, as was the level dependence.

At 63 Hertz (center), there was a slight maximum at the sound channel axis, apparently still some wind dependence, but a higher variability.

At 10 Hertz (next left), the trend is similar to 63 Hertz, but with even a greater variability.

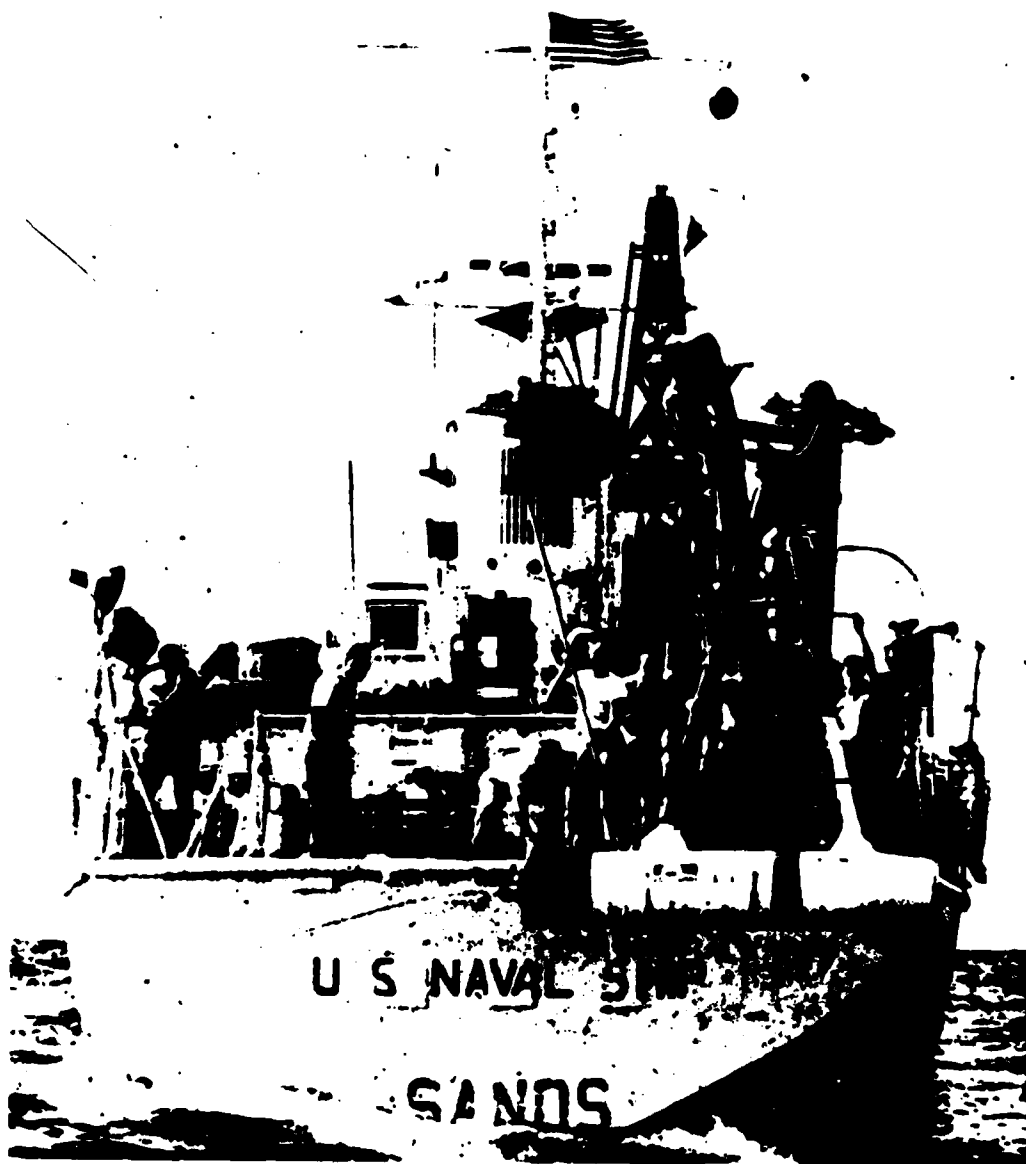
More data were required to sort things out; vertical directionality measurements would logically be the next step.

## DIRECTIONAL AUTOBUOY WITH VERTICAL LINE ARRAY



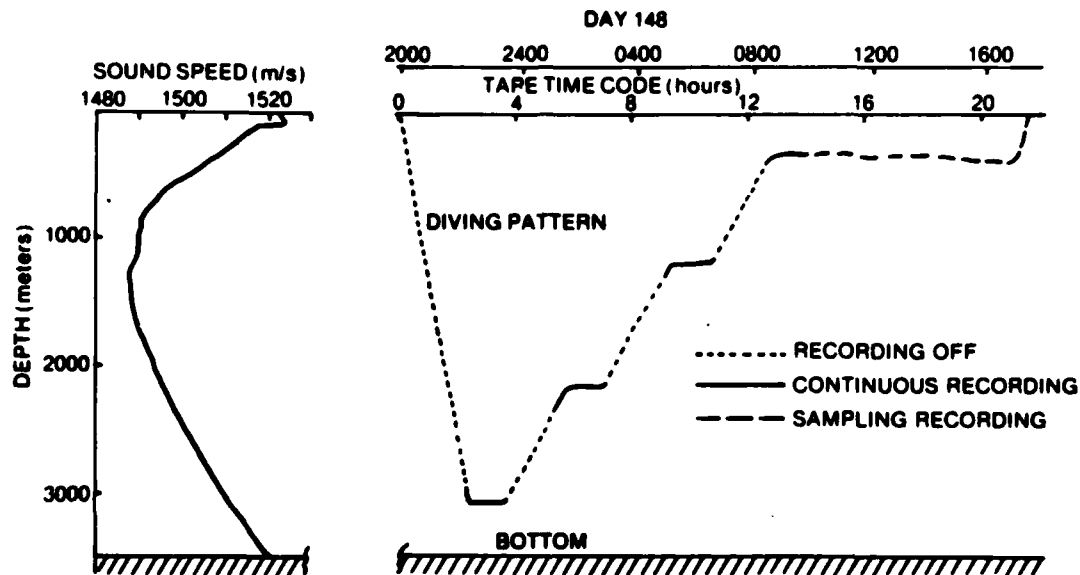
Slide 3

The measurement system used was the self-contained, free-floating Autobuoy system equipped with a new 12-element vertical array, which was 237 meters long. The world-traveled Autobuoy can be programmed to hover at selected depths and presently has an 8-hour recording capability.



Slide 4

To get a perspective on the size of the Autobuoy, it is shown here in a pre-deployment mode over the stern of an AGOR ship. The only practical limitation regarding noise measurements is a reluctance to deploy and retrieve in high sea states.



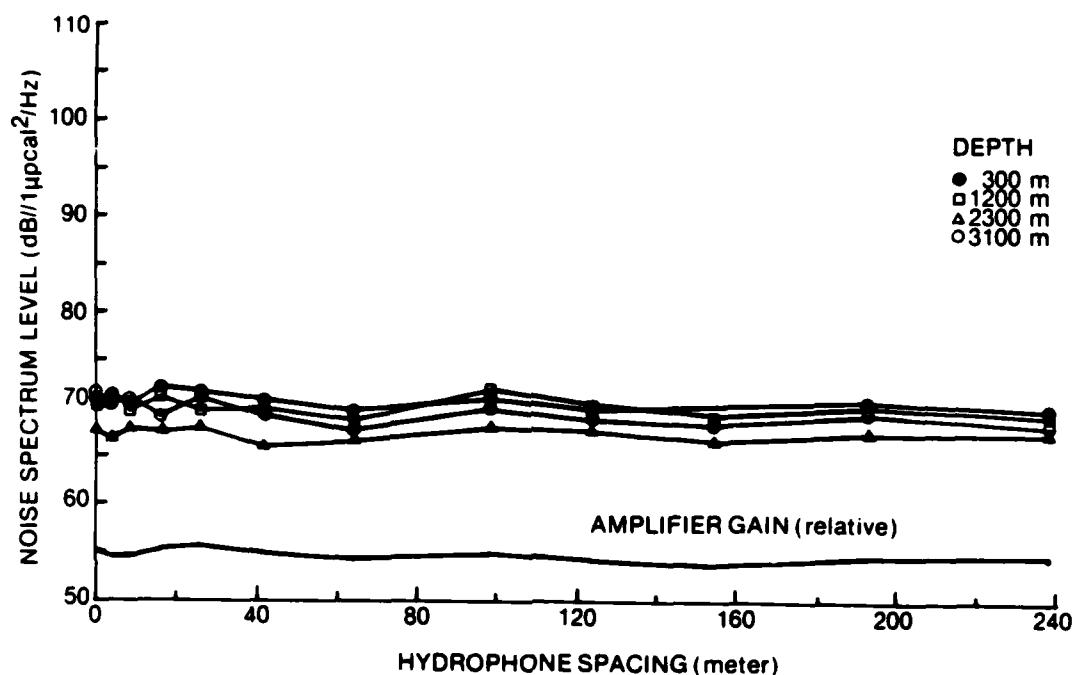
## Slide 5

A chronology of the data collection is shown here along with the measured sound speed profile. The sound speed profile (on the left) was marginally bottom limited.

The Autobuoy hovered at four consecutive recording stations, starting at a depth of 3100 meters (relatively near the bottom).

Stations were then made at 2200 meters (a deep intermediate depth), 1200 meters (the sound channel axis), and 300 meters (a shallow intermediate depth).

Approximately 1 hour of data was obtained at each station.

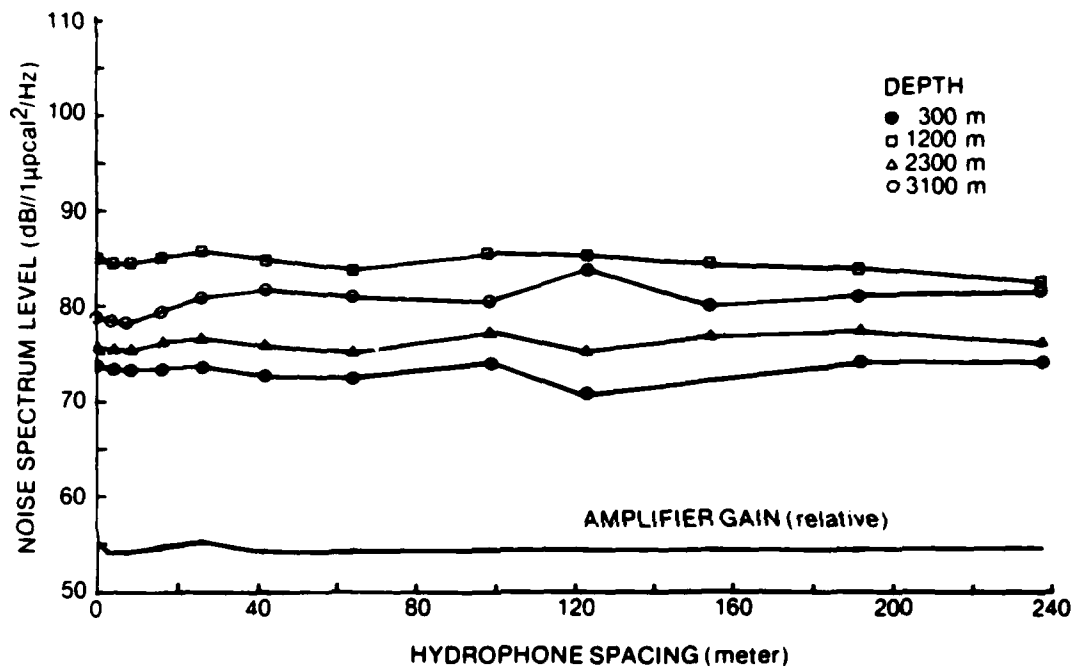


### Slide 6

First, we examined single hydrophone data to see if the results were similar to previous omnidirectional data.

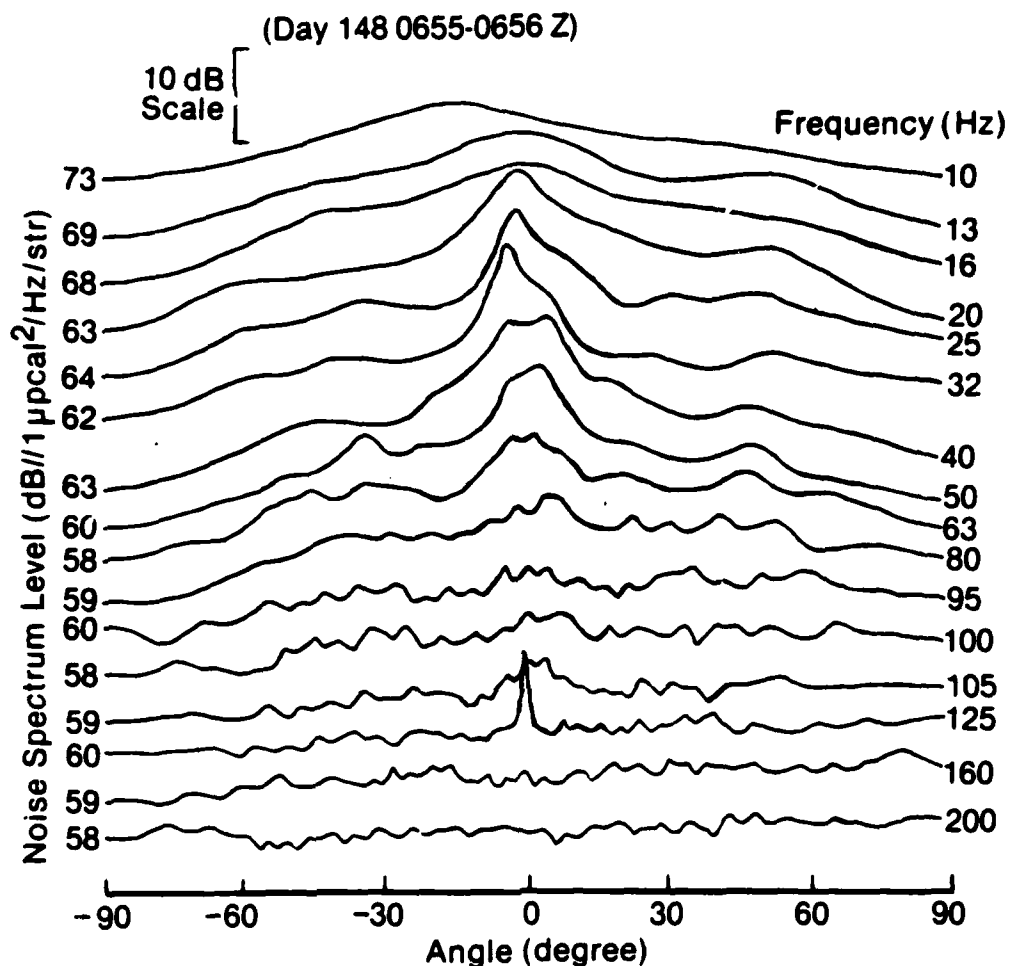
At 200 Hertz, shown here, we have plotted data for each of the 12 array elements as a function of array spacing, which is logarithmic, at each of the four depth stations. The symbols for each of these four stations are shown in the upper right.

The change across the array for a given station is small, with the highest average level occurring for the shallowest station (300 meters), as one would expect for wind-generated noise. The measured levels were as expected for the local average wind speed, which was 18 knots for all four stations.



Slide 7

At 25 Hertz, the change with depth is greater (over 10 dB) with the maximum level now occurring at the sound channel axis (1200 meters). The Autobuoy data are consistent with the previously reported omnidirectional data taken with the Moored Acoustic Buoy System (MABS).



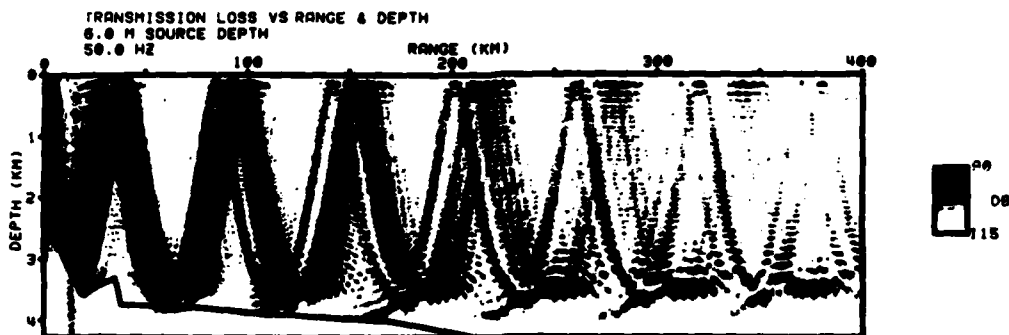
Slide 8

The first vertical directionality results shown are for the sound channel axis (1200-meter depth). The frequency band listing is on the right. The horizontal direction is given as  $0^\circ$ , hence upward looking angles are positive, downward negative.

At 200 Hertz, shown at the bottom, the level is essentially flat for all angles. As we go to lower frequencies a broad maximum develops, centered at the sound channel axis. This broad peak becomes sharper below 50 Hertz.

This broad peak is similar to that observed by Anderson in the North Pacific. Normally one expects coupling to the deep sound channel from a shallow source to result in peaks at typically  $\pm 15^\circ$  with a relative minimum at  $0^\circ$ . Anderson suggested that the sloping sound channel axis in the North Pacific might improve the coupling for small angles. Unfortunately, we do not have such a shallow sound channel axis in the Fiji Basin.

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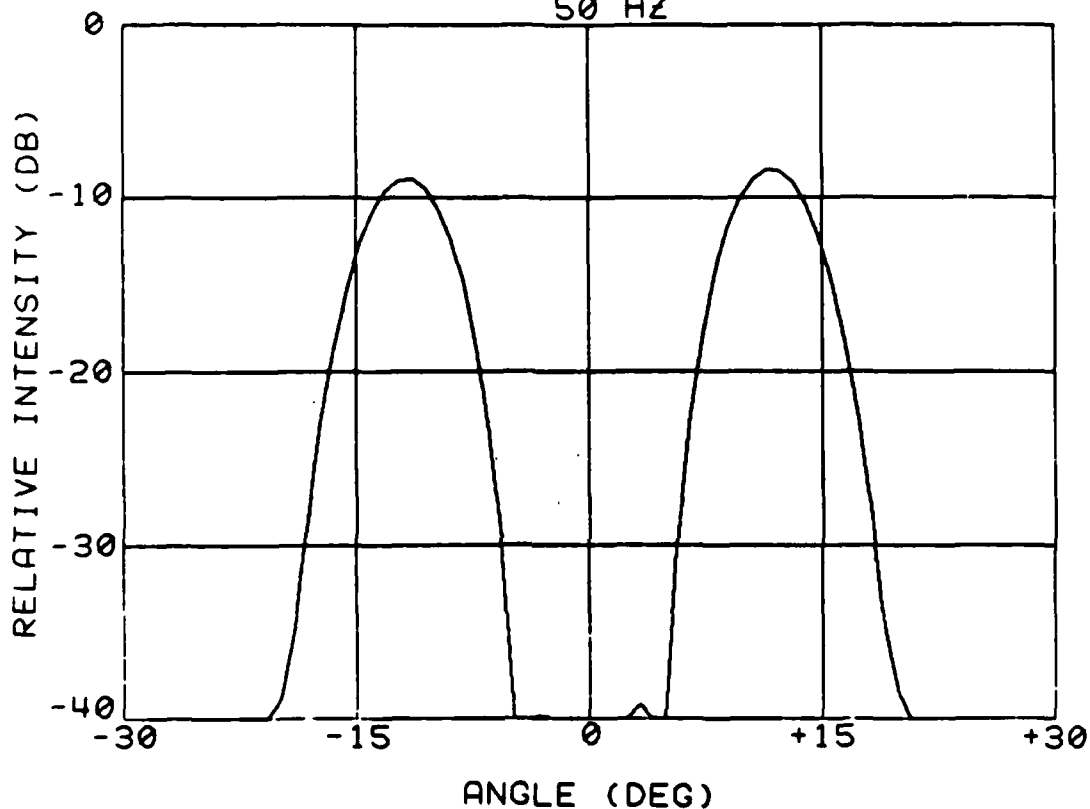


Slide 9

The other possibility, as mentioned earlier, is slope enhanced coupling by the surrounding ridge systems.

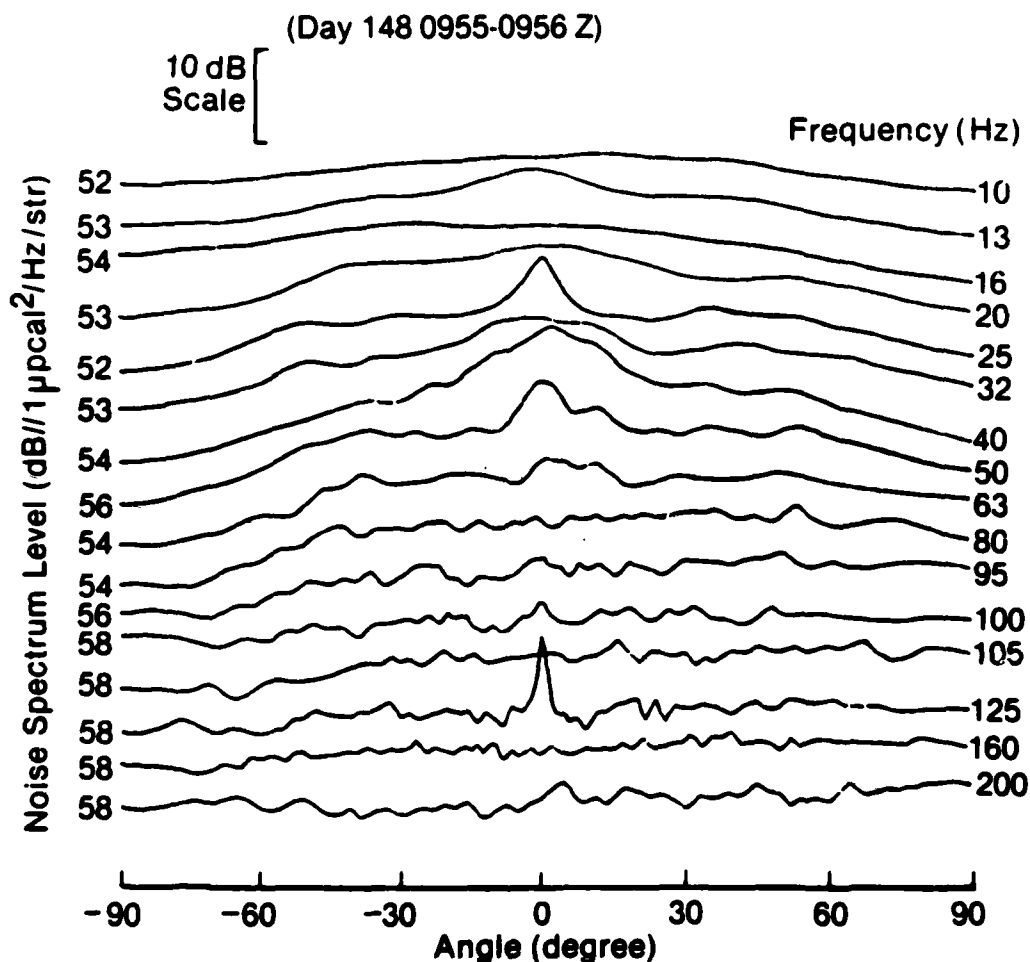
Thanks to Drs. Stephen Wales and Orest Diachuck of the Large Aperture Arrays Branch of the Naval Research Laboratory, we have obtained predictions of the vertical noise directionality due to such coupling for our measurements in the Fiji Basin. Shown here is transmission loss versus range and depth for a 6-meter source depth over one of the ridges at a frequency of 50 Hz.

AVERAGE INTENSITY VS VERTICAL ARRIVAL ANGLE  
350-450 KM RANGE  
1250 M RECEIVER DEPTH  
6 M SOURCE DEPTH  
50 HZ



Slide 10

The prediction of vertical directionality has twin peak levels at  $\pm 12^\circ$  with a large drop at  $0^\circ$ . For a reasonable estimate of contributing ships (typically 5), the general level is compatible with the measured level, but the angular distribution is not. It should be noted that we took a typical ridge height, but greater enhancement would be possible from the Fiji Rise. Perhaps a better approach would be to consider the highest ridge that may dominate the enhancement.



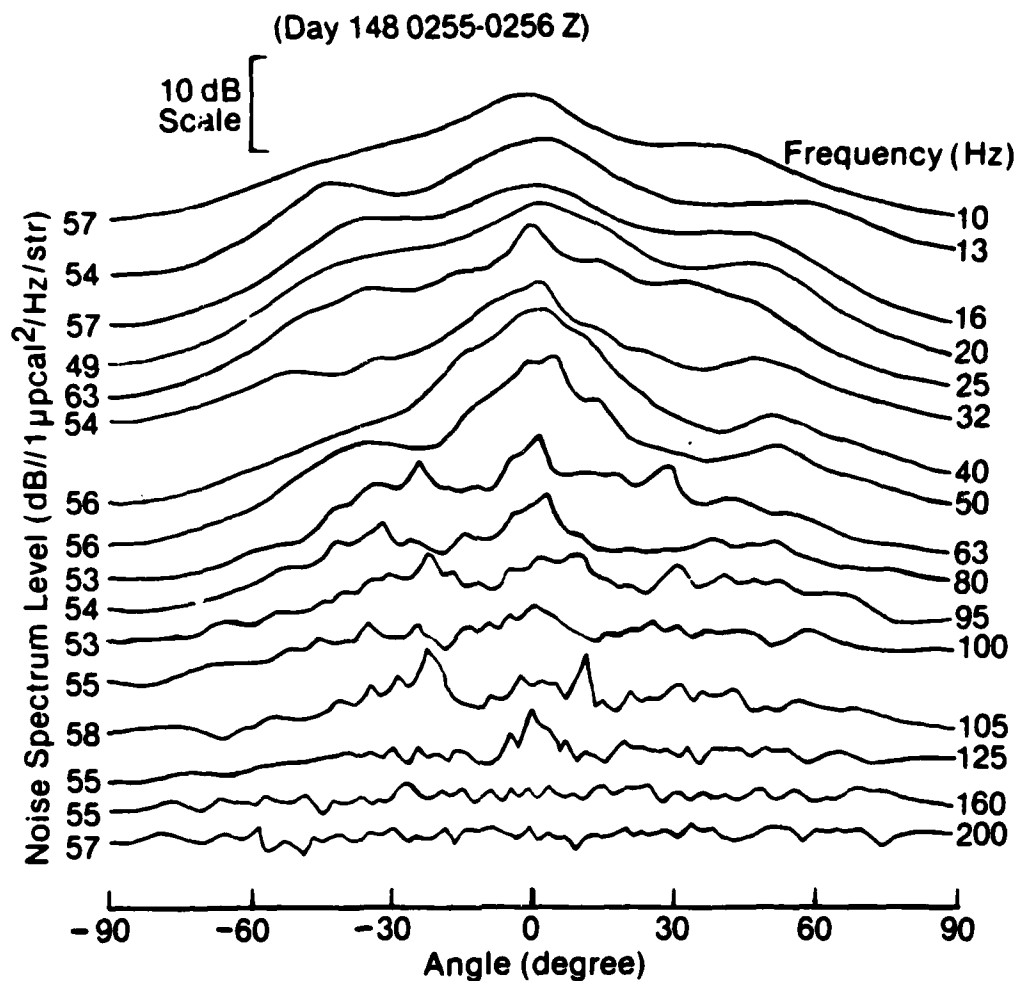
## Slide 11

For the shallowest station (300 meters), the low frequency peak is less pronounced.

Starting at the 200 Hertz curve, there is a slight tilt toward the upward angles indicating an increased level near the surface, which is expected for wind-generated noise.

This may, in part, be the cause of the apparent lessening in the peak since the surrounding background level is increased.

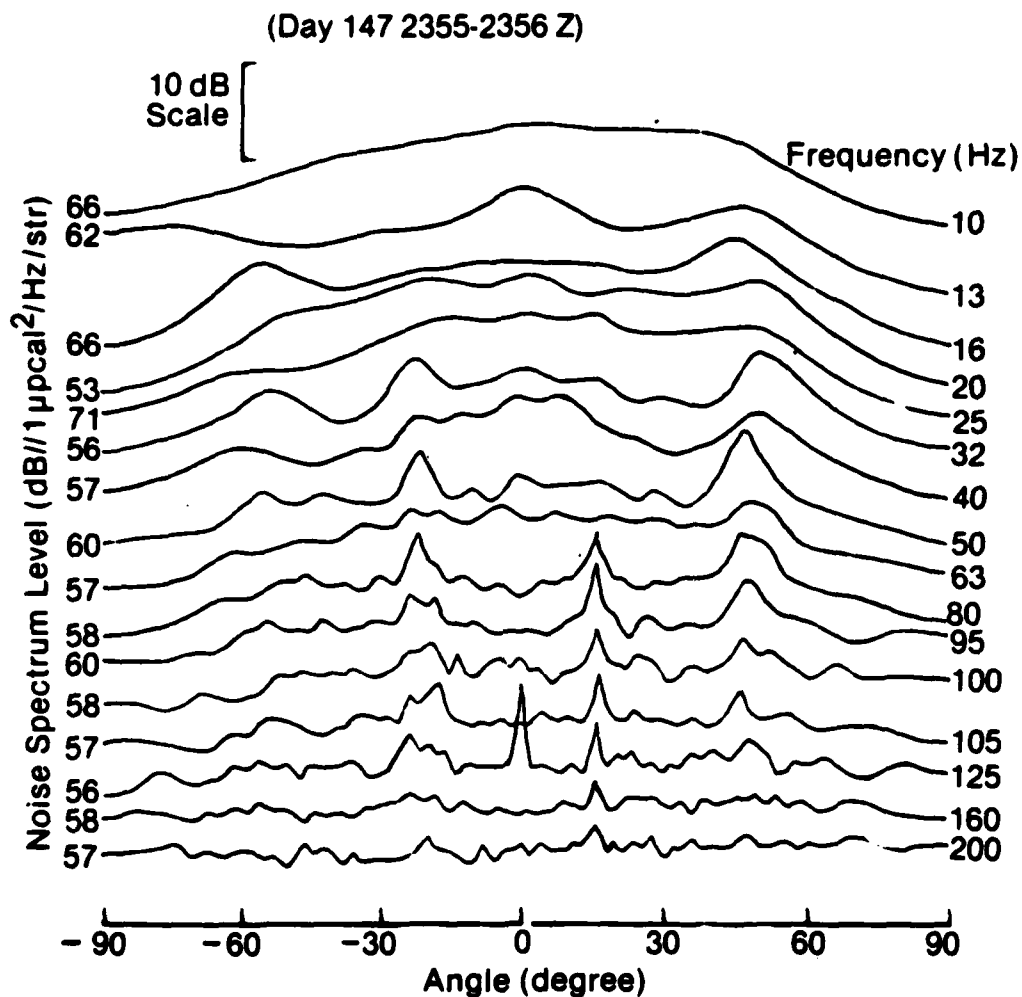
The corresponding predictions (300 meter depth) due to slope enhancement, again, provide the required level increase, but still are not a broad peak, but rather a double peak — this time at  $\pm 8^\circ$  and a 15 dB dip at  $0^\circ$ .



Slide 12

At the deep intermediate depth (2200 meters), the broad peak becomes what can be best described as ragged. We believe that this does not indicate a basic change in the peak, but rather the addition of another noise component — a reliable acoustic path (RAP) type propagation from a single ship in the area.

The predictions are similar in character to the two previous depths, in this case twin peaks at  $\pm 6^\circ$  and a 10-dB dip at  $0^\circ$ . What we are suggesting as single ship arrivals, such as at  $-28^\circ$ , are clearly outside this peak.



Slide 13

At the deepest station (3100 meters), this additional single-ship component is more clearly defined, as would be expected. Note these peaks at -20°, +16°, and +47°.

Albeit reduced, the broad maximum still remains.

## Conclusions

**Above 200 Hz noise constant with depth.**

**Below 200 Hz broad maximum centered at sound channel axis.**

**Results compatible with slope coupling or far distant shipping.**

### Slide 14

We can summarize our results, which were at an average 18 knot wind speed as follows:

- Above 200 Hertz, the noise level is relatively constant throughout the water column, with a slight increase near the surface. All evidence points to locally wind-generated noise.
- Below 200 Hertz, a broad maximum centered at the sound channel axis develops. This can be masked to some extent by other noise components.
- Results from predictions of slope-coupled shipping or far distant shipping are compatible with the levels observed at the broad maximum, although the shape is not. This comparison is not yet definitive and seismic activity or storm noise cannot be ruled out.

Hopefully, the horizontal directivity measurements planned for the South Fiji Basin this spring by the Joint Defence Scientific Establishment/Naval Research Laboratory will resolve the principal source of low frequency noise.

Thank you.

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